UNIVERSITY OF ILLINOIS

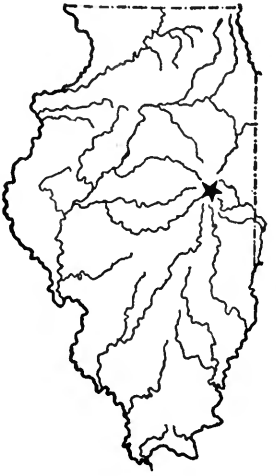
Agricultural Experiment Station

BULLETIN No. 169

A STUDY OF THE ASH CONTENT OF GROWING PIGS

WITH SPECIAL REFERENCE TO THE INFLUENCE OF THE QUANTITY OF PROTEIN CONSUMED

By R. H. WILLIAMS and A. D. EMMETT



URBANA, ILLINOIS, MAY, 1914

Contents of Bulletin No. 169

A STUDY OF THE ASH CONTENT OF GROWING PIGS

WITH SPECIAL REFERENCE TO THE INFLUENCE OF THE QUANTITY OF PROTEIN CONSUMED [a]

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INTRODUCTION

That the nature and composition of the body tissues can be modified to a greater or less extent by certain feeds has been demonstrated by various investigators. Thus, the feeding of different kinds of fats, or feeds containing characteristic fats, in some instances affects the adipose tissue distinctly.[1] The addition of certain mineral elements to a ration otherwise sufficient causes a marked increase in the body gains, improves the general condition of the animal, and affects the physical properties of the bones.[2] How the composition of the tissues is affected by the added mineral elements has not been demonstrated.

In the case of rations that differ essentially in their content of nitrogenous and non-nitrogenous nutrients, the more highly nitrogenous rations may increase the milk yield, improve the quality of the butter,[3] and influence the gains in weight, the general condition of the animals, and the size of some of the vital organs,[4] tho they do not seem to have any effect upon the physical and chemical properties of the protein produced or the gross chemical composition of the tissues.[5]

Rations that contain equivalent amounts of *different kinds* of protein obtained from different feeds produce different effects upon the development of the animal.[6] Apparently, however, they do not affect the forms of nitrogen in the blood or tissue, or the physical constants of the fats.[7]

[a] The results presented in this bulletin, together with those given in Bulletin 171 of this station, formed part of a thesis submitted by R. H. Williams to the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Husbandry.

[1] This and similar reference numbers refer to the bibliography on pages 158 and 159.

When the *amount* of protein consumed is varied, and the other nutrients in the ration are maintained as uniform as possible, it has been found in this laboratory that the general physical condition of the animal is altered, tho apparently the gross composition of the tissues and the physical constants of the fats are not affected.[8]

The ultimate object of the investigation of which this publication is a partial report was to determine the influence of different quantities of protein upon the nutrition of *young growing* pigs.[8] This particular bulletin gives the experimental data relating to the ash content of the animal body, and is divided into three parts. The first part deals with the influence of the quantity of protein consumed upon the ash content of the pigs; the second, with the average ash content of pigs 40 to 43 weeks of age; and the third, with the changes in the ash content of pigs that occur during growth.

THE EXPERIMENT

The plan of the experiment is given in detail in Bulletin 168 of this station. Briefly, it may be described as follows: Of fourteen carefully selected Berkshire pigs weighing on an average 51 pounds, two were slaughtered and analyzed at the beginning of the experiment for a control. The remaining twelve were then divided into three lots of four each in such a way that all of the lots were as nearly alike as possible in regard to age, ancestry, weight, and condition. Lot I was fed a low-protein ration, Lot II, a medium-protein ration, and Lot III, a high-protein ration. Each ration consisted of ground corn, blood meal, and calcium phosphate. In the low-protein ration, one-half of the protein was derived from the ground corn, and one-half from the blood meal; in the medium-protein ration, 20 percent of the protein was furnished by the corn, and 80 percent by the blood meal; and in the high-protein ration, 14 percent of the protein came from the corn, and 86 percent from the blood meal. All of the pigs received the same amount of ground corn per 100 pounds live weight. The calcium phosphate[a] was so fed that the rations of Lots I, II, and III contained, respectively, 11.03, 9.65, and 8.73 grams of phosphorus per 100 pounds live weight. In addition, each pig was offered, once a week, about 35 grams of charcoal and 5 grams of salt. They did not seem to show any special desire for either, however, and often left a considerable portion.

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[a]According to the results of Hart, McCollum, and Fuller (Wis. Agr. Exp. Sta. Res. Bul. 1), calcium phosphates are as efficient in supplementing rations low in phosphorus as are organic phosphorus compounds. These investigators state that young growing pigs should receive per day at least 6 to 10 grams of phosphorus per 100 pounds live weight.

The animals had free access to water and were allowed the freedom of their paved pens. As they grew older and fatter, they were given additional exercise.

The average amounts of feeds, nutrients, and energy consumed per 100 pounds live weight are given in Table 1.

Effect of Rations.—The experiment lasted 174 days. During this time the differences in the general physical condition and appearance of the pigs became very noticeable. Briefly, the findings were as follows: The pigs of Lot I, the low-protein group, developed slowly, remained small, and appeared to be unthrifty and undernourished. As the experiment progressed, they became sluggish, and, toward the end, walked with difficulty. Pig 2 became so ill that it was removed on the forty-first day and given the ration of the Station herd. It died a week later. Two of the three remaining pigs in this lot died before the close of the experiment. The kidneys of these pigs were small and in a pathological condition, showing a chronic state of parenchymatous nephritis. The remaining pig, No. 1, which at the beginning of the experiment was considered to be the most thrifty of the animals selected, made fair gains, averaging 0.64 pound per day. However, the kidneys of this animal also were found to be small and in the same pathological condition as those of the other two. The livers were small, but otherwise normal.

Early in the experiment, when Pig 2 died, one pig was removed from each of Lots II and III in order to make the three lots directly comparable from the standpoint of merit of the animals, number of animals, and area per head in each pen.

The remaining pigs of the medium- and high-protein lots showed practically none of the unfavorable symptoms apparent in the pigs of Lot I, tho at times during very cold weather they were stiff in the hind quarters. In general, however, these animals were thrifty and active, and had good appetites. Also, considering that they were kept in pens, they made good gains, Lot II averaging 0.96 pound per pig per day, and Lot III, 0.94 pound.

Since the chief and essential difference between the rations given Lots I, II, and III was in their content of protein, it would seem that a deficiency of protein in the feed was the chief cause of the poor development of the animals of Lot I.

Attention should again be called to the fact that the pigs used in this investigation were young growing animals weighing on an average only 51 pounds at the beginning of the experiment, and that they were housed in small pens paved with brick. The reader is cautioned against assuming that similar results would have been obtained if they had been more mature.

Animals Slaughtered and Analyzed.—Both of the pigs of Lot IV, Nos. 26 and 44, were slaughtered and analyzed at the beginning of the experiment for a control. These animals were by the same sire and

TABLE 1.—FEEDS, NUTRIENTS, AND ENERGY CONSUMED PER DAY PER 100 POUNDS LIVE WEIGHT

Lot	Animal	Feeds			Digestible nutrients						Ash	Phosphorus	Calcium[b]	Metabolizable energy[c]	Nutritive ratio
		Ground corn	Blood meal	Total	Dry substance	Protein (N x 6.25)			Carbohydrates	Fat					
						Ground corn	Blood meal	Total							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*grams*	*grams*	*grams*	*therms*	
I	1	2.29	0.22	2.51	1.97	0.16	0.16	0.32	1.55	0.061	71.24	11.03	4.07	3.79	1:5.3
	3[a]	2.40	0.13	2.54	1.99	0.13	0.13	0.26	1.62	0.064	.....	....	....	3.90	1:6.8
	4[a]	1.58	0.18	1.76	1.38	0.12	0.12	0.24	1.07	0.042	.....	....	....	2.65	1:4.9
II	5	2.14	0.78	2.92	2.27	0.14	0.57	0.71	1.45	0.059	65.26	9.65	3.56	4.32	1:2.2
	7	2.11	0.76	2.87	2.23	0.14	0.55	0.69	1.43	0.059	63.42	9.65	3.56	4.24	1:2.3
	8	1.91	0.72	2.64	2.05	0.13	0.52	0.65	1.29	0.053	53.98	7.71	2.72	3.88	1:2.2
Average	..	2.05	0.75	2.81	2.18	0.14	0.54	0.68	1.39	0.057	60.88	9.00	3.28	4.14	1:2.2
III	16	1.92	1.10	3.02	2.34	0.13	0.80	0.93	1.29	0.055	57.45	8.73	3.22	4.41	1:1.5
	13	2.00	1.14	3.14	2.43	0.13	0.83	0.96	1.35	0.057	60.67	8.73	3.22	4.58	1:1.5
	15	1.82	0.92	2.75	2.13	0.11	0.68	0.79	1.23	0.052	55.34	8.16	3.22	4.02	1:1.7
Average	..	1.91	1.05	2.97	2.30	0.12	0.77	0.89	1.29	0.055	57.82	8.54	3.22	4.33	1:1.6

[a] Died before close of experiment.

[b] Calculated from average composition of feeds.

[c] The metabolizable energy of a ration is the energy that can be liberated in the animal body, or the gross energy less the energy contained in the feces, urine, and intestinal gases. The metabolizable energy of the rations has been calculated by multiplying the weights of the digestible nutrients by the following factors: digestible protein, 1860; digestible carbohydrates, 1905; and ether extract, 3992. One therm equals 1000 calories.

of the same age. At the time that they were slaughtered they weighed 61.0 and 54.7 pounds, respectively. The pigs chosen for slaughter and chemical study at the close of the experiment were Nos. 1 of Lot I, 5 and 7 of Lot II, and 16 and 13 of Lot III. At the time they were slaughtered these animals weighed, respectively, 180.1, 249.4, 199.6, 248.4, and 189.3 pounds. Pigs 1, 5, and 16 were of the same age. They were also related, No. 1 being a litter mate of No. 5, and No. 16 being by the same sire as Nos. 1 and 5. Pigs 7 and 13 were litter mates and twenty days younger than Nos. 1, 5, and 16.

Seven composite samples were prepared from each pig of Lots I, II, and III. These were: (1) the offal, consisting of the organs of the respiratory, circulatory, and digestive systems, the brain, the spinal cord, the kidneys, the urinary organs, etc.; (2) the blood; (3) the skeleton; (4) the jowl, leaf, and intestinal fats; (5) the boneless meat of the ham cut; (6) the boneless meat of the side cut; and (7) the boneless meat of the shoulder cut. These samples represented integral parts of the entire body, and from the determinations of their weights and composition the chemical composition of the boneless meat of the dressed carcass and the entire body of each pig was calculated. Only four composite samples were prepared from each pig of Lot IV, i. e., offal, skeleton, composite of the jowl, leaf, and intestinal fats, and boneless meat of the carcass.

Methods of Analysis.—The samples were analyzed in the fresh condition. The determinations made were for the total ash and water-soluble ash, the usual precautions being taken to prevent any loss or fusion. The soluble ash was extracted according to a modification of the method formerly used in this laboratory.[9]

INFLUENCE OF QUANTITY OF PROTEIN CONSUMED

Total Ash.—The data in Tables 2 and 3 give the percentage of total ash calculated to the fresh substance and to the dry and fat-free substance for the various parts of the slaughtered pigs. On comparing the data in Table 2 for each of the parts of the pigs in Lot I, II, and III, it will be seen that in the case of the offal, the jowl, leaf, and intestinal fats, and the ham cut, there was but a slight difference between the lots and the individuals in the lots. In the case of the blood, skeleton, carcass, and entire body, the differences between the average values of the lots as a whole were considerably smaller than those between the values for the animals within the lots. On comparing the corresponding data of the pigs of Lots II and III, Pig 5 with Pig 16, and Pig 7 with Pig 13, it will be noted that there was no consistent relation between the values for the ash and the values for the amounts of protein consumed.

The data for the jowl, leaf, and intestinal fats, and the boneless meat of the shoulders, sides, and carcasses of the pigs of Lots II and III show differences within each lot that were as great as, or greater than, those between the lots. Further, the differences between the values for the corresponding animals of the lots were not consistent.

The data for the dry and fat-free substance given in Table 3 show that the results for the offal, blood, skeleton, and entire body were slightly lower for the pigs of Lot III than for those of Lot II. Thus, the average percentages of ash for Lots III and II, respectively, were: in the offal, 5.00 and 5.54; in the blood, 11.53 and 13.26; in the skeleton, 57.21 and 59.09; and in the entire body, 20.55 and 22.66.

On comparing the data for Lot I with those for the other lots, it will be noted that in the large majority of cases the values for the former fell midway between the values within Lots II and III. Thus, the percentage of ash in the blood of Pig 1 of Lot I was 12.22, while the percentages for Pigs 5 and 7 were 14.66 and 11.85, respectively. The percentage of ash in the skeleton of Pig 1 was 56.58, while the percentages in the skeletons of Pigs 16 and 13 of Lot III were 58.52 and 55.90, respectively.

TABLE 2.—TOTAL ASH IN THE BODY AND ITS PARTS

(Results expressed in percent of fresh substance)

Lot	Animal	Offal[a]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat				Entire body
						Ham	Shoulder	Side	Carcass	
I	1	1.18	2.45	31.83	0.13	0.76	0.83	0.63	0.72	4.14
II	5	1.25	2.84	36.54	0.14	0.83	0.70	0.50	0.62	3.83
II	7	1.17	2.25	33.33	0.19	0.78	0.78	0.67	0.72	4.65
Average . . .	..	1.21	2.54	34.93	0.16	0.80	0.74	0.58	0.67	4.24
III	16	1.16	2.53	35.46	0.17	0.82	0.81	0.61	0.71	3.91
III	13	1.18	2.31	31.52	0.18	0.75	0.67	0.55	0.63	3.80
Average . . .	..	1.17	2.42	33.49	0.17	0.78	0.74	0.58	0.67	3.85
Average (5)	..	1.19	2.48	33.74	0.16	0.79	0.76	0.59	0.68	4.07
IV	26	1.11	(b)	23.59	0.35	(b)	(b)	(b)	1.59	3.59
IV	44	1.11	(b)	25.14	0.32	(b)	(b)	(b)	1.43	3.23
Average . . .	..	1.11	(b)	23.37	0.33	(b)	(b)	(b)	1.51	3.37

[a] Includes blood.

[b] Not analyzed.

TABLE 3.—TOTAL ASH IN THE BODY AND ITS PARTS

(Results expressed in percent of dry and fat-free substance)[a]

Lot	Animal	Offal[b]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat				Entire body
						Ham	Shoulder	Side	Carcass	
I	1	5.60	12.22	56.58	4.91	4.57	5.65	4.87	5.04	21.59
II	5	5.57	14.66	58.88	4.36	5.18	4.89	4.66	4.86	21.12
II	7	5.51	11.85	59.30	5.31	4.83	5.64	5.97	5.53	24.21
Average . . .	..	5.54	13.26	59.09	4.84	5.00	5.26	5.21	5.19	22.66
III	16	4.77	12.05	58.52	6.05	5.25	5.26	5.35	5.31	20.56
III	13	5.23	11.02	55.90	5.41	4.72	4.72	4.63	4.87	20.54
Average . . .	..	5.00	11.53	57.21	5.73	4.97	4.99	5.49	5.09	20.55
Average (5)	..	5.34	12.36	57.83	5.21	4.91	5.23	5.10	5.12	21.60
IV	26	5.73	(c)	53.67	5.05	(c)	(c)	(c)	9.08	17.45
IV	44	5.74	(c)	55.08	5.97	(c)	(c)	(c)	8.93	16.64
Average . . .	..	5.74	(c)	54.37	5.51	(c)	(c)	(c)	9.00	17.04

[a]Calculated from data given in Tables 4 and 5.

[b]Includes blood.

[c]Not analyzed.

TABLE 4.—DRY SUBSTANCE IN THE BODY AND ITS PARTS

(Results expressed in percent of fresh substance by summation)

Lot	Animal	Offal[a]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat				Entire body
						Ham	Shoulder	Side	Carcass	
I	1	35.74	20.05	66.13	91.76	47.47	52.66	63.32	56.69	56.15
II	5	35.49	19.38	67.97	90.55	47.99	51.05	66.09	58.38	57.13
II	7	33.85	18.98	66.89	86.72	46.92	53.98	68.64	59.52	57.43
Average . . .	..	34.67	19.18	67.43	88.63	47.45	52.51	67.36	58.95	57.28
III	16	36.71	20.99	65.32	90.89	49.65	49.80	68.30	59.11	57.78
III	13	35.43	20.95	63.99	87.83	50.20	52.26	66.28	58.81	56.43
Average . . .	..	36.07	20.97	64.65	89.36	49.92	51.03	67.29	58.96	57.10
Average (5)	..	35.44	20.07	66.06	89.55	48.45	51.95	66.53	58.50	56.98
IV	26	35.02	(b)	50.91	84.28	(b)	(b)	(b)	38.36	38.83
IV	44	35.29	(b)	49.22	81.48	(b)	(b)	(b)	43.94	41.82
Average . . .	..	35.15	(b)	50.06	82.88	(b)	(b)	(b)	41.15	40.32

[a] Includes blood.

[b] Not analyzed.

TABLE 5.—FAT IN THE BODY AND ITS PARTS

(Results expressed in percent of fresh substance)

Lot	Animal	Offal[a]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat				Entire body
						Ham	Shoulder	Side	Carcass	
I	1	11.96	(b)	12.15	89.06	30.85	37.96	50.38	42.41	36.90
II	5	10.53	(b)	8.15	87.43	31.96	36.74	55.36	45.60	38.98
II	7	10.16	(b)	10.54	83.09	30.76	40.14	57.42	46.44	38.24
Average	..	10.34	(b)	9.35	85.26	31.36	38.44	56.39	46.02	38.61
III	16	9.60	(b)	6.46	88.08	34.04	34.40	56.89	45.68	38.75
III	13	10.68	(b)	9.44	84.58	34.23	38.06	55.42	45.89	37.93
Average	..	10.14	(b)	7.95	86.33	34.14	36.23	56.15	45.79	38.34
Average (5) .	..	10.58	(b)	9.35	86.45	32.37	37.72	55.09	45.20	38.16
IV	26	15.16	(b)	6.96	77.41	(b)	(b)	(b)	20.81	18.24
IV	44	15.89	(b)	7.21	76.12	(b)	(b)	(b)	27.91	22.39
Average	..	15.52	(b)	7.08	76.76	(b)	(b)	(b)	24.36	20.32

TABLE 6.—DISTRIBUTION OF TOTAL ASH AMONG THE PARTS OF THE BODY

(Results expressed in percent of ash in entire body)

Lot	Animal	Offal[a]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat			
						Ham	Shoulder	Side	Carcass
I	1	5.62	1.79	83.37	0.23	2.57	3.58	4.62	10.76
II	5	6.38	2.62	82.92	0.26	3.01	2.97	4.45	10.43
II	7	5.69	1.83	82.16	0.26	2.82	3.78	5.32	11.92
Average	..	6.03	2.22	82.54	0.26	2.91	3.37	4.88	11.16
III	16	5.60	1.97	82.16	0.31	3.04	3.71	5.17	11.92
III	13	6.40	2.12	82.94	0.32	2.72	3.06	4.53	10.31
Average	..	6.00	2.04	82.55	0.31	2.88	3.38	4.85	11.11
Average (5)	..	5.94	2.07	82.71	0.28	2.83	3.42	4.82	11.07
IV	26	11.12	(b)	65.97	0.13	(b)	(b)	(b)	22.79
IV	44	12.83	(b)	63.93	0.17	(b)	(b)	(b)	23.08
Average	..	11.97	(b)	64.95	0.15	(b)	(b)	(b)	22.93

[a]Includes blood.

[b]Not analyzed.

In Table 6 the distribution of the ash in the different parts of each pig has been expressed in percent of the total ash in the entire body. When the corresponding data for Lots I, II, and III are compared, it becomes apparent that the distribution of the ash was not affected by the differences in the protein content of the rations.

Water-Soluble Ash.—The data for the water-soluble ash are given in Tables 7, 8, 9, and 10. The values for the three lots on the basis of the fresh substance, given in Table 7, agree remarkably well for the various parts. Thus, in the case of the offal, the average values were 1.00, 1.02, and 1.02 percent for Lots I, II, and III, respectively. The minimum value was 0.94 percent for Pig 7 of Lot II, and the maximum value, 1.11 percent for Pig 5 of Lot II.

The data for the dry and fat-free substance, given in Table 8, indicate nothing definite as to the influence of the quantity of protein consumed. The differences between the values for the various parts show that neither the averages nor the values for the corresponding pigs of the lots followed any general trend, and there was no correlation with the age, ancestry, type, or condition of the pigs. In some cases the corresponding values agreed closely, as in the ham cut. In other cases, as in the offal, they varied considerably. Thus, the value for Pig 5 was greater than that for Pig 16, and the value for Pig 7 was lower than that for Pig 13. Further, as in the side cut, the individual differences in some instances were very great in comparison with the lot differences. The same statements are true regarding the data when expressed in percent of the total soluble ash for the entire body (Table 9), and also when calculated in percent of the total ash in each of the parts (Table 10).

From the above facts it would seem, therefore, that the distribution of the total and water-soluble ash in the bodies of the pigs was not affected by the differences in the amounts of protein consumed, and that the chief and fundamental differences noted in these constituents were due, in the main, to individuality.

TABLE 7.—WATER-SOLUBLE ASH IN THE BODY AND ITS PARTS
(Results expressed in percent of fresh substance)

Lot	Animal	Offal[a]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat				Entire body
						Ham	Shoulder	Side	Carcass	
I	1	1.00	2.45	0.56	0.101	0.70	0.66	0.54	0.64	0.64
II	5	1.11	2.84	0.50	0.114	0.64	0.61	0.43	0.61	0.60
II	7	0.94	2.25	0.52	0.155	0.71	0.60	0.45	0.60	0.59
Average	..	1.02	2.54	0.51	0.134	0.68	0.61	0.44	0.60	0.59
III	16	1.02	2.53	0.53	0.118	0.64	0.55	0.46	0.61	0.60
III	13	1.02	2.31	0.55	0.135	0.67	0.63	0.44	0.61	0.61
Average	..	1.02	2.42	0.54	0.126	0.65	0.64	0.45	0.61	0.60
Average (5) . .	..	1.02	2.48	0.53	0.125	0.67	0.63	0.46	0.61	0.61

TABLE 8.—WATER-SOLUBLE ASH IN THE BODY AND ITS PARTS
(Results expressed in percent of dry and fat-free substance)

Lot	Animal	Offal[a]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat				Entire body
						Ham	Shoulder	Side	Carcass	
I	1	4.56	12.22	0.99	3.73	4.21	4.49	4.17	4.48	3.28
II	5	4.81	14.66	0.80	3.66	3.99	4.26	4.01	4.77	3.30
II	7	4.28	11.85	0.93	4.26	4.39	4.34	4.01	4.59	3.07
Average	..	4.54	13.26	0.86	3.96	4.19	4.30	4.01	4.68	3.18
III	16	4.00	12.05	0.88	4.20	4.10	4.22	4.03	4.54	3.16
III	13	4.44	11.02	0.98	4.15	4.20	4.44	3.70	4.72	3.30
Average	..	4.22	11.53	0.93	4.18	4.15	4.33	3.86	4.63	3.23
Average (5) .	..	4.42	12.36	0.92	4.00	4.18	4.35	3.98	4.62	3.22

[a]Includes blood.

TABLE 9.—DISTRIBUTION OF WATER-SOLUBLE ASH AMONG THE PARTS OF THE BODY

(Results expressed in percent of soluble ash in entire body)

Lot	Animal	Offal[a]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat			
						Ham	Shoulder	Side	Carcass
I	1	30.73	11.55	9.37	1.13	15.27	18.22	25.24	58.73
II	5	35.76	16.55	7.10	1.38	14.71	16.49	24.25	55.74
II	7	30.38	12.04	8.46	1.37	17.03	19.23	23.76	60.02
Average	..	33.07	14.29	7.78	1.37	15.87	17.86	24.15	57.88
III	16	31.20	12.78	7.97	1.37	15.29	19.07	25.09	59.45
III	13	34.52	13.04	8.96	1.49	14.86	17.81	22.34	55.01
Average	..	32.86	12.91	8.46	1.43	15.07	18.44	23.71	57.22
Average (5).....	..	32.52	13.19	8.37	1.35	15.43	18.16	24.19	57.79

TABLE 10.—RELATIVE SOLUBILITY OF TOTAL ASH OF THE BODY AND ITS PARTS

(Results expressed in percent of total ash in each)

Lot	Animal	Offal[a]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat				Entire body
						Ham	Shoulder	Side	Carcass	
I	1	80.67	100.00	1.75	75.94	92.13	79.11	84.70	88.89	15.71
II	5	85.95	100.00	1.36	83.82	77.31	87.80	87.35	98.38	15.99
II	7	76.14	100.00	1.57	80.31	91.89	77.32	67.81	83.33	15.40
Average	..	81.04	100.00	1.46	82.07	84.60	82.56	77.58	90.85	15.70
III	16	83.26	100.00	1.50	69.41	77.75	79.46	75.00	85.92	15.61
III	13	95.62	100.00	1.76	76.70	88.48	94.47	79.96	96.83	16.46
Average	..	89.44	100.00	1.63	73.06	83.11	86.96	77.48	91.37	16.04
Average (5)..	..	84.35	100.00	1.59	77.24	85.51	83.63	78.96	90.67	15.84

[a]Includes blood.

AVERAGE ASH CONTENT OF GROWING PIGS 40 TO 43 WEEKS OLD

It is evident from the data in the preceding section of this bulletin that the quantities and the distribution of the ash in the bodies of the pigs were not significantly affected by the differences in the quantities of protein consumed. Accordingly, the average values for the five pigs slaughtered may be regarded as representing approximately the average ash content of pigs 40 to 43 weeks of age.

Total Ash.—The total ash in the fresh substance (Table 11) varied from 0.16 percent in the jowl, leaf, and intestinal fats, to 33.74 percent in the skeleton. The offal contained 1.19 percent, and the blood, 2.48 percent. The ash in the boneless meat was comparatively low, ranging from 0.59 to 0.79 percent, and averaging for the carcass, 0.68 percent. The ash content of the entire body was 4.07 percent. The ratio of the ash in the entire body to the ash in the skeleton on the basis of the fresh substance was as 1 :8.5.

On the basis of the dry and fat-free substance, the ash value for the offal, the jowl, leaf, and intestinal fats, and the carcass were nearly the same. Thus, the offal contained 5.34 percent, the jowl, leaf, and intestinal fats, 5.21 percent, and the carcass, 5.12 percent. The ash content of the skeleton was 57.83 percent. The ratio between the ash values of the entire body and those of the skeleton was 1 :2.7.

The percentage distribution of the ash in terms of the total ash in the body indicated that the values ranged from 0.28 in the jowl, leaf, and intestinal fats to 82.71 percent in the skeleton. The boneless meat of the carcass contained 11.07 percent of the entire ash, being made up of 2.83 percent from the ham, 3.42 percent from the shoulder, and 4.82 percent from the side. The blood made up only 2.07 percent, and the offal, 5.94 percent.

Water-Soluble Ash.—The data in Table 11 for the soluble ash expressed on the basis of the fresh substance had a much smaller range than those for the total ash. The jowl, leaf, and intestinal fats contained the smallest percentage, i. e., 0.12 percent, and the blood, the highest percentage, i. e., 2.48 percent. The most marked differences between the values for the water-soluble ash and those for the total ash were found in the skeleton, in which the soluble ash made up 0.53 percent, and the total ash, 33.74 percent. With the exception of the values for the entire body, the corresponding data for the soluble ash in the offal, the jowl, leaf, and intestinal fats, and the boneless meat of the ham, shoulder, side, and carcass were but slightly lower than the value for the total ash. In the case of the entire body, the percentage of soluble ash was 0.61 as compared with 4.07, the percentage for the total ash. The values for the ham, shoulder, carcass, and entire body were almost the same.

The percentage of soluble ash on the basis of dry and fat-free substance was lowest in the skeleton and highest in the blood. Like the total ash, the values for the offal, the jowl, leaf, and intestinal fats, and the ham, shoulder, and carcass showed slight variations, ranging from 3.98 percent in the boneless meat of the side cut to 4.62 percent in the boneless meat of the carcass. The percentage of soluble ash in the entire body was 3.22. These data indicate, as did those

TABLE 11.—AVERAGE ASH CONTENT OF PIGS OF LOTS I, II, AND III

	Offal[a]	Blood	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat				Entire body
					Ham	Shoulder	Side	Carcass	
Total Ash									
In percent of fresh substance	1.19	2.48	33.74	0.16	0.79	0.76	0.59	0.68	4.07
In percent of dry and fat-free substance	5.34	12.36	57.83	5.21	4.91	5.23	5.10	5.12	21.60
In percent of total ash in entire body	5.94	2.07	82.71	0.28	2.83	3.42	4.82	11.07	100.00
Water-Soluble Ash									
In percent of fresh substance	1.02	2.48	0.53	0.12	0.67	0.63	0.46	0.61	0.61
In percent of dry and fat-free substance	4.42	12.36	0.92	4.00	4.18	4.35	3.98	4.62	3.22
In percent of total soluble ash in entire body	32.52	13.19	8.37	1.35	15.43	18.16	24.19	57.79	100.00
In percent of total ash in each part	84.33	100.00	1.59	77.24	85.51	83.63	78.96	90.67	15.84

[a]Includes blood.

for the fresh substance, that the greatest difference between the percentages of soluble and total ash was in the skeleton and the entire body.

The distribution of the soluble ash in the body showed that the jowl, leaf, and intestinal fats contained the smallest percentage, 1.35, and the carcass, the largest percentage, 57.79. These values were both about five times greater than those for the total ash. As in the case of the total ash, the ham cut had the lowest value for soluble ash, and the side cut, the highest. These data were also about five times as great as those for the total ash. The percentage of soluble ash in the skeleton was 8.37, while that of the total ash was 82.71. In the blood, the soluble ash made up 13.19 percent, and the total ash 2.07 percent. In the offal, the values for soluble and total ash, respectively, were 32.52 and 5.94 percent.

The relative solubility of the total ash of each of the parts varied greatly. It was lowest in the skeleton, 1.59 percent, and highest in the boneless meat of the carcass, 90.67 percent. The values for the offal, the ham, and the shoulder cuts were about the same, being 84.33, 85.51, and 83.63 percent, respectively. Likewise, the data for the jowl, leaf, and intestinal fats, and the side cut ran close, being 77.24 percent for the former and 78.96 percent for the latter. Of the total ash in the entire body, 15.84 percent was soluble in cold water.

CHANGES IN TOTAL ASH CONTENT OF PIGS DURING GROWTH

The young pigs of Lot IV were used as a control to determine approximately the chemical changes that took place in the pigs of Lots I, II, and III from the beginning to the close of the experiment. The average data for the two pigs of Lot IV and for the five pigs of Lots I, II, and III, obtained from Tables 2 to 9, are given in Table 12.

The age of the pigs in Series I, when slaughtered, was 18 weeks; that of Pigs 1, 5, and 16 of Series II, 42 weeks and 6 days; and that of Pigs 7 and 13 of Series II, 40 weeks.

No data has been given in Table 12 for the blood and the boneless meat of the ham, shoulder, and side cuts, as these parts were not analyzed separately in the case of the young pigs. Data for the water-soluble ash also have been omitted, as they were not determined in any of the samples from Lot IV.

On studying the data for the total ash on the basis of the fresh substance (Table 12) it will be noted that in the case of the offal the percentage values for the pigs of the two series were virtually the same, i. e., 1.11 and 1.19, respectively. On the other hand, the percentage of ash in the skeleton was 23.37 for Series I, and 33.74 for Series II. The percentage of ash in the jowl, leaf, and intestinal fats ranged from 0.16 to 0.33, the higher values being those for the younger pigs. In the carcass, the average percentage of ash was 1.51 for Series I, and 0.68 for Series II, the values for the young pigs being more than double those for the older pigs. In the case of the entire body, the value for the pigs of Series I was slightly lower, being 3.37 percent as compared with 4.07 percent, the value for the older animals.

On the basis of the dry and fat-free substance, the corresponding percentages of ash in the offal and the jowl, leaf, and intestinal fats were practically the same, being 5.74 and 5.34, respectively, for the former, and 5.51 and 5.21 for the latter. The values for the skeleton and the entire body were lower in Series I than in Series II, those for the skeleton being 54.37 and 57.83 percent, and those for the entire body, 17.04 and 21.60 percent, respectively. In the case of the boneless meat of the carcass, the younger pigs had a much higher percentage of ash than the more mature pigs, the value for the former being 9.00, and that for the latter, 5.12.

In the distribution of the ash among the parts in percent of the ash of the entire body, the pigs of Series I had twice as much ash in the offal and the boneless meat of the carcass as those of Series II, 78.5 percent as much in the skeleton, and about 50 percent as much in the jowl, leaf, and intestinal fats.

TABLE 12.—TOTAL ASH CONTENT OF PIGS AS AFFECTED BY GROWTH

	Offal[a]	Skeleton	Jowl, leaf, and intestinal fats	Boneless meat of carcass	Entire body	Ratio: Boneless meat to skeleton
Series I. Average of Lot IV. Pigs 18 weeks of age						
In percent of fresh substance	1.11	23.37	0.33	1.51	3.37	1:15.5
In percent of dry and fat-free substance	5.74	54.37	5.51	9.00	17.04	1: 6.0
In percent of total ash in entire body	11.97	64.95	0.15	22.93	100.00	1: 2.9
Series II. Average of Lots I, II, and III. Pigs 40 to 43 weeks of age						
In percent of fresh substance	1.19	33.74	0.16	0.68	4.07	1:49.6
In percent of dry and fat-free substance	5.34	57.83	5.21	5.12	21.60	1:11.3
In percent of total ash in entire body	5.94	82.71	0.28	11.07	100.00	1: 7.5

[a]Includes blood.

When the ash in the skeleton is expressed in terms of the ash of the boneless meat of the carcass, the data show that the ratios decreased with the age of the pigs. Thus, on the basis of the fresh substance, the values were 1:15.5 for Series I, and 1:49.6 for Series II; on the basis of the dry and fat-free substance, 1:6.0 for Series I, and 1:11.3 for Series II; and in percent of the total ash of the entire body, 1:2.9 for Series I, and 1:7.5 for Series II.

SUMMARY

1. *Plan of Experiment.*—Of fourteen carefully selected Berkshire pigs weighing on an average 51 pounds, two were slaughtered and analyzed at the beginning of the experiment to be used as a control in studying the influence of the feed on growth. The remaining twelve were then divided into three lots of four pigs each in such a way that the lots were as nearly alike as possible in regard to age, ancestry, weight, and condition. During the experiment, which lasted 174 days, Lot I was fed a low-protein ration (0.32 pound of digestible protein per day per 100 pounds live weight); Lot II, a medium-protein ration (0.70 pound of digestible protein per day per 100 pounds live weight); and Lot III, a high-protein ration (0.94 pound of digestible protein per day per 100 pounds live weight). Each ration consisted of ground corn, blood meal, and calcium phosphate. All of the pigs received the same amounts of corn protein per 100 pounds live weight. The blood-meal protein made up 50 percent of the total protein received by the pigs of Lot I, 80 percent of that received by Lot II, and 86 percent of that received by Lot III. Lot I received 3.79 therms of metabolizable energy per 100 pounds live weight per day; Lot II, 4.28 therms; and Lot III, 4.49 therms. The calcium phosphate was so fed that the rations of Lots I, II, and III contained, respectively, 11.09, 9.65, and 8.73 grams of phosphorus per 100 pounds live weight per day. The pigs of the three lots were kept and fed under exactly the same conditions thruout the experiment. Each pig was fed separately. At the end of the experiment the bodies and parts of one pig of Lot I and two pigs from each of Lots II and III were analyzed for total and water-soluble ash.

INFLUENCE OF QUANTITY OF PROTEIN CONSUMED

2. *Total Ash in the Lots.*—The percentages of total ash in the bodies and the parts of the bodies of the low-, medium-, and high-protein lots, respectively, were as follows: composite sample of jowl, leaf, and intestinal fats, 0.13, 0.16, and 0.17; boneless meat of side cut, 0.63, 0.58, and 0.58; boneless meat of carcass, 0.72, 0.67, and 0.67; boneless meat of shoulder cut, 0.83, 0.74, and 0.74; boneless meat of

ham cut, 0.76, 0.80, and 0.78; offal, 1.18, 1.21, and 1.17; blood 2.45, 2.54, and 2.42; entire body, 4.14, 4.24, and 3.85, and skeleton, 31.83, 34.93, and 33.49.

3. *Distribution of Total Ash in the Lots.*—The percentage distribution of the total ash in the bodies of the low-, medium-, and high-protein lots, respectively, was as follows: composite sample of jowl, leaf, and intestinal fats, 0.23, 0.26, and 0.31; blood, 1.79, 2.22, and 2.04; boneless meat of ham cut, 2.57, 2.91, and 2.88; boneless meat of shoulder cut, 3.58, 3.37, and 3.38; boneless meat of side cut, 4.62, 4.88, and 4.85; offal, 5.62, 6.03, and 6.00; boneless meat of carcass, 10.76, 11.16, and 11.11, and skeleton, 83.37, 82.54, and 82.55.

4. *Water-Soluble Ash in the Lots.*—The percentages of water-soluble ash in the bodies and the parts of the bodies of the low-, medium-, and high-protein lots, respectively, were as follows: composite sample of jowl, leaf, and intestinal fats, 0.101, 0.134, and 0.126; boneless meat of side cut, 0.54, 0.44, and 0.45; skeleton, 0.56, 0.51, and 0.54; boneless meat of carcass, 0.64, 0.60, and 0.61; entire body, 0.64, 0.59, and 0.60; boneless meat of shoulder cut, 0.66, 0.61, and 0.64; boneless meat of ham, 0.70, 0.68, and 0.65; offal, 1.00, 1.02, and 1.02; and blood, 2.45, 2.54, and 2.42.

5. *Distribution of Water-Soluble Ash in the Lots.*—The percentage distribution of the water-soluble ash in the bodies of the low-, medium-, and high-protein lots, respectively, was as follows: composite sample of jowl, leaf, and intestinal fats, 1.13, 1.37, and 1.43; skeleton, 9.37, 7.78, and 8.46; blood, 11.55, 14.29, and 12.91; boneless meat of ham cut, 15.27, 15.87, and 15.07; boneless meat of shoulder cut, 18.22, 17.86, and 18.44; boneless meat of side cut, 25.24, 24.15, and 23.71; offal, 30.73, 33.07, and 32.86; and boneless meat of carcass, 58.73, 57.88, and 57.22.

AVERAGE ASH CONTENT OF GROWING PIGS 40 TO 43 WEEKS OLD

6. *Ash Content of Entire Body.*—The average percentages of total and water-soluble ash in the entire bodies of the five pigs were 4.07 and 0.61, respectively. On the basis of the dry and fat-free substance, the values were 21.60 and 3.22 percent, respectively. Of the total ash in the entire body, 15.84 percent was soluble in water.

7. *Distribution of Ash Among the Parts of the Body.*—The percentage distribution of the total ash in the bodies of the five pigs was as follows: composite sample of jowl, leaf, and intestinal fats, 0.28; blood, 2.07; boneless meat of ham cut, 2.83; boneless meat of shoulder cut, 3.42; boneless meat of side cut, 4.82; offal, 5.94; boneless meat of carcass, 11.07; and skeleton, 82.71. The percentage distribution of the soluble ash in the bodies of the five pigs was as follows: composite sample of jowl, leaf, and intestinal fats, 1.35; skeleton, 8.37; blood,

13.19; boneless meat of ham, 15.43; boneless meat of shoulder, 18.16; boneless meat of side cut, 24.19; offal, 32.52; and boneless meat of carcass, 57.79.

8. *Ash Content of Boneless Meat of Carcass.*—The average percentages of total and soluble ash in the boneless meat of the carcasses of the five pigs were 0.68 and 0.61, respectively. On the basis of the dry and fat-free substance, the values were 5.12 and 4.62 percent, respectively. Of the total ash in the boneless meat of the carcasses, 90.67 percent was soluble in water.

9. *Ash Content of Skeleton (Bone and Marrow).*—The average percentages of total and soluble ash in the skeletons of the five pigs were 33.74 and 0.53, respectively. On the basis of the dry and fat-free substance, the values were 57.83 and 0.92 percent, respectively. Of the total ash in the skeleton, 1.59 percent was soluble in water.

CHANGES IN TOTAL ASH CONTENT OF PIGS DURING GROWTH

10. *Ash Content of Entire Body.*—The percentages of total ash in the bodies and the parts of the bodies of the pigs 18 weeks of age and of those 40 to 43 weeks of age, respectively, were as follows: composite of jowl, leaf, and intestinal fats, 0.33 and 0.16; offal, 1.11 and 1.19; boneless meat of carcass, 1.51 and 0.68; entire body, 3.37 and 4.07; and skeleton, 23.37 and 33.74.

11. *Distribution of Total Ash.*—The percentage distribution of the total ash in the bodies of the young and older pigs, respectively, was as follows: composite of jowl, leaf, and intestinal fats, 0.15 and 0.28; offal, 11.97 and 5.94; boneless meat of carcass, 22.93 and 11.07; and skeleton, 64.95 and 82.71.

12. *Ratios of Total Ash in Boneless Meat to Total Ash in Skeleton.*—The ratios of the total ash in the boneless meat to the total ash in the skeletons of the young and older pigs, respectively, were as follows: on the basis of the fresh substance, 1:15.5 and 1:49.6; on the basis of the dry and fat-free substance, 1:6.0 and 1:11.3; and on the basis of the percentage of total ash in the entire body, 1:2.9 and 1:7.5.

CONCLUSIONS

From the experimental data given in this bulletin, the following conclusions may be drawn:

1. Variations in the amounts of digestible protein consumed from 0.32 pound to 0.94 pound per 100 pounds live weight per day, do not influence significantly the percentages or distribution of the total or water-soluble ash in the bodies or the parts of the bodies of growing pigs.

2. The total ash in the bodies of pigs 40 to 43 weeks old is distributed among the parts as follows: somewhat more than four-fifths

in the skeleton, about one-ninth in the boneless meat of the carcass, and about one-sixteenth in the offal, blood, and the composite of the jowl, leaf, and intestinal fats combined. Of the water-soluble ash, somewhat less than three-fifths is to be found in the boneless meat of the carcass, about one-third in the offal, the blood, and the composite of the jowl, leaf, and intestinal fats, and about one-twelfth in the skeleton.

3. The percentages of total ash in the bodies and the parts of the bodies of pigs 40 to 43 weeks of age are significantly different from the corresponding percentages for pigs 18 weeks of age. The offal and carcasses of the younger animals contain practically twice as much as those of the older pigs, while the skeletons contain only about three-fourths as much. The ratios of the total ash in the boneless meat to the total ash in the skeletons of the older animals are also distinctly different from the corresponding ratios for the younger animals. As the pigs become older, the ratio of total ash in the boneless meat of the carcass to total ash in the skeleton decreases, while the ratio of total ash in the entire body to total ash in the skeleton remains approximately constant.

The authors wish to express to Professor H. S. Grindley, Chief in Animal Nutrition, their appreciation of his valuable advice and suggestions given in connection with this research. They are indebted for assistance also to Dr. W. E. Joseph, Associate in Animal Husbandy, and Professor William Dietrich, formerly Assistant Chief in Swine Husbandry. To Miss Leonora Perry they wish to express their appreciation of her very efficient editorial criticism.

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